Visual Navigation for Flying Robots – Project

Autonomous Landing on a Moving Platform

presented by
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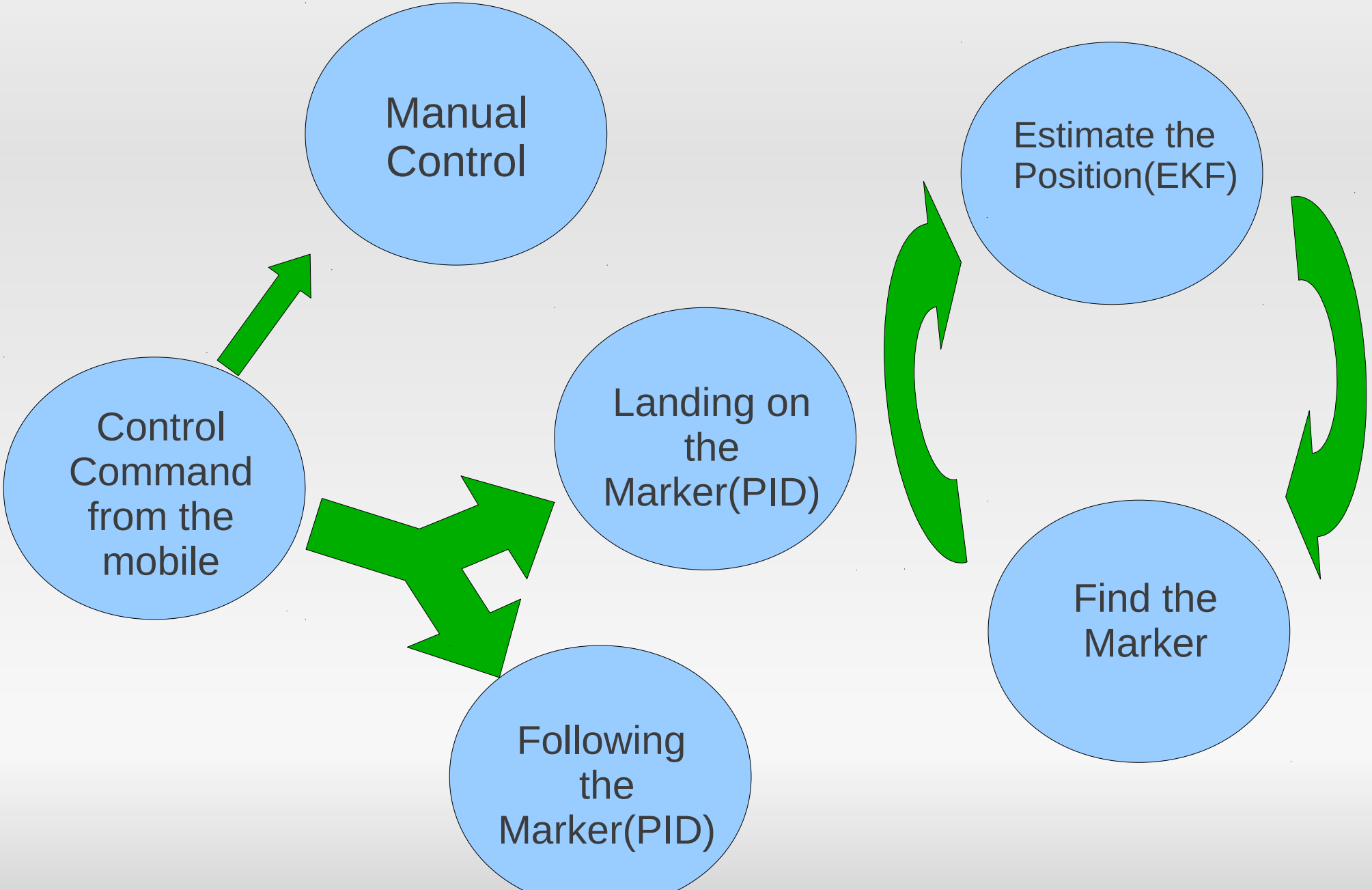
Motivation

- Controlled landing in difficult environments
- Following the marker implicitly
- Control with the Android Smartphone

State Graph

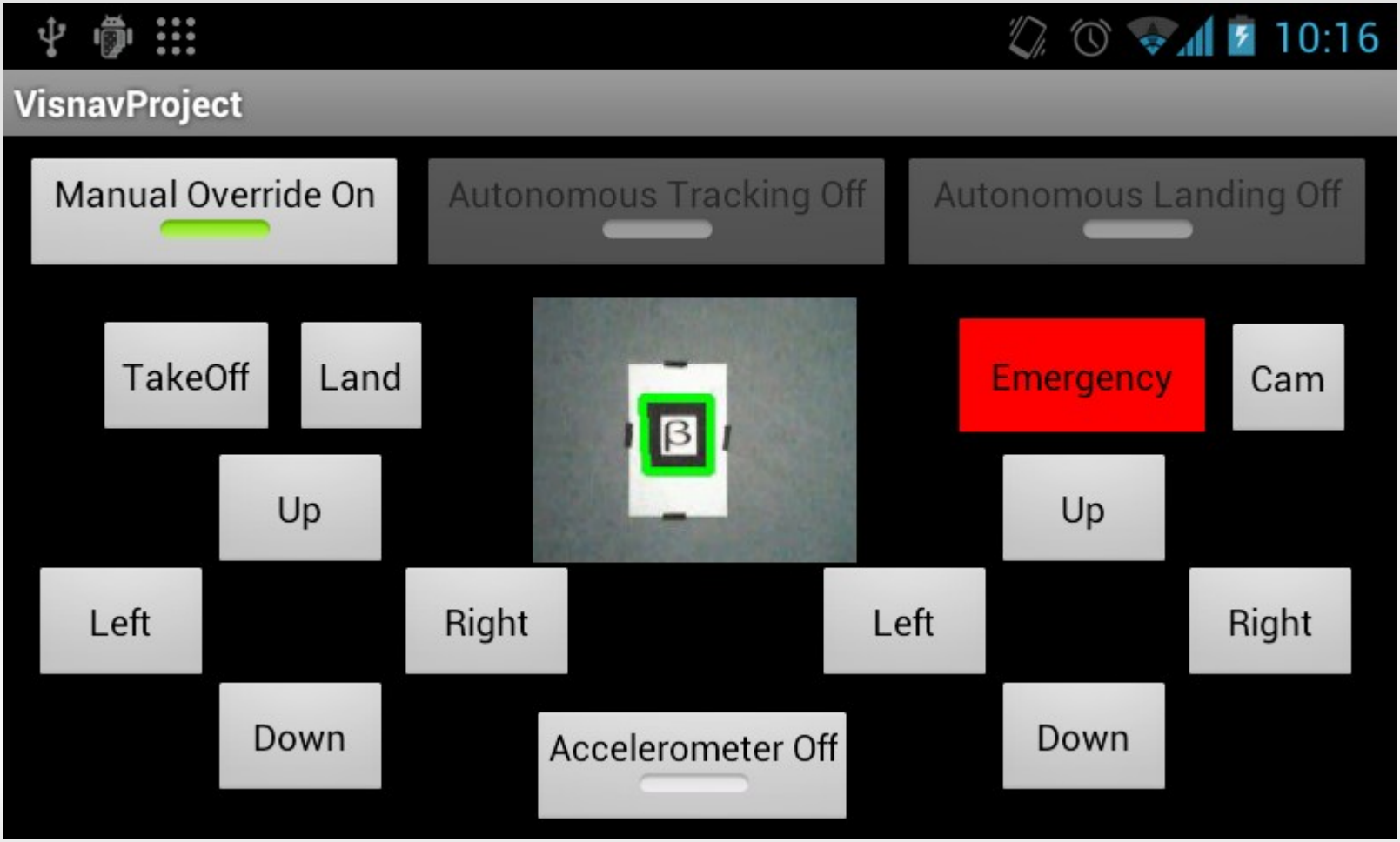

Manual Control
Control Command from the mobile
Landing on the Marker(PID)
Following the Marker(PID)
Estimate the Position(EKF)
Find the Marker

Two parts of the project

- Project was split into two tasks:
  - Android interface – Sebastian Nagel
  - Controlling the ARDrone – Ross Kidson, Karol Hausman

Android Interface

- User Interface for the mobile phone



Android Interface - Technologies

- **Rosjava** – ROS client library purely in Java
- **Android_core** – package developed by Google to integrate Rosjava clients in Android projects

Android Interface - Rosjava

- Main differences to roscpp:
  - Asynchronous:
    - because of heavy dependence on network communication
  - More threads, fewer processes
    - No spin() method!
    - Many nodes in one JVM process – similar to nodelets
    - Use in memory communication

Android Interface - Android_core

- Android_core libraries:
  - Classes to use Rosjava in Android applications (Master chooser, RosActivity, …)
  - Tutorial projects and sample implementations of ROS nodes in Android Views (e.g. RosImageView)

Android Interface - Implementing

- ARDroneRemote node
  - Publisher/Subscriber for communication with controller:

```
// State publisher, autonomous availability subscriber
private Publisher<std_msgs.Int32> pubState;
private Subscriber<std_msgs.Bool> subAvailable;
```

  - Publisher/Subscriber for communication with ARDrone driver:

```
// Manual control publishers
private Publisher<std_msgs.Empty> pubTakeOff, pubLand, pubEmergency;
private Publisher<geometry_msgs.Twist> pubVel;
```

Android Interface - Implementing

- Example code
  - Creating new publisher in onStart() of NodeMain:

```
@Override
public void onStart(ConnectedNode node) {
  // State control
  pubState = node.newPublisher("/visnav/state", std_msgs.Int32._TYPE);
  [...]
}
```

  - Publishing a message:

```
public void setState(State state) {
    Int32 msg = pubState.newMessage();
    msg.setData(state.ordinal());
    pubState.publish(msg);
    [...]
}
```

Autonomous Part - Plan

- Use Kalman Filter for localization of the ARDrone(detecting the first marker)
- Try to detect another marker and set it as the goal for the PD controller
- Follow the detected moving marker
- Land on the moving marker if the quadrocopter is stable enough

Autonomous Part - Following

- Two different marker following approaches:
  - Use one marker for both EKF positioning and moving marker tracking
  - Use one marker for tracking and another one for EKF positioning

Autonomous Part - Landing

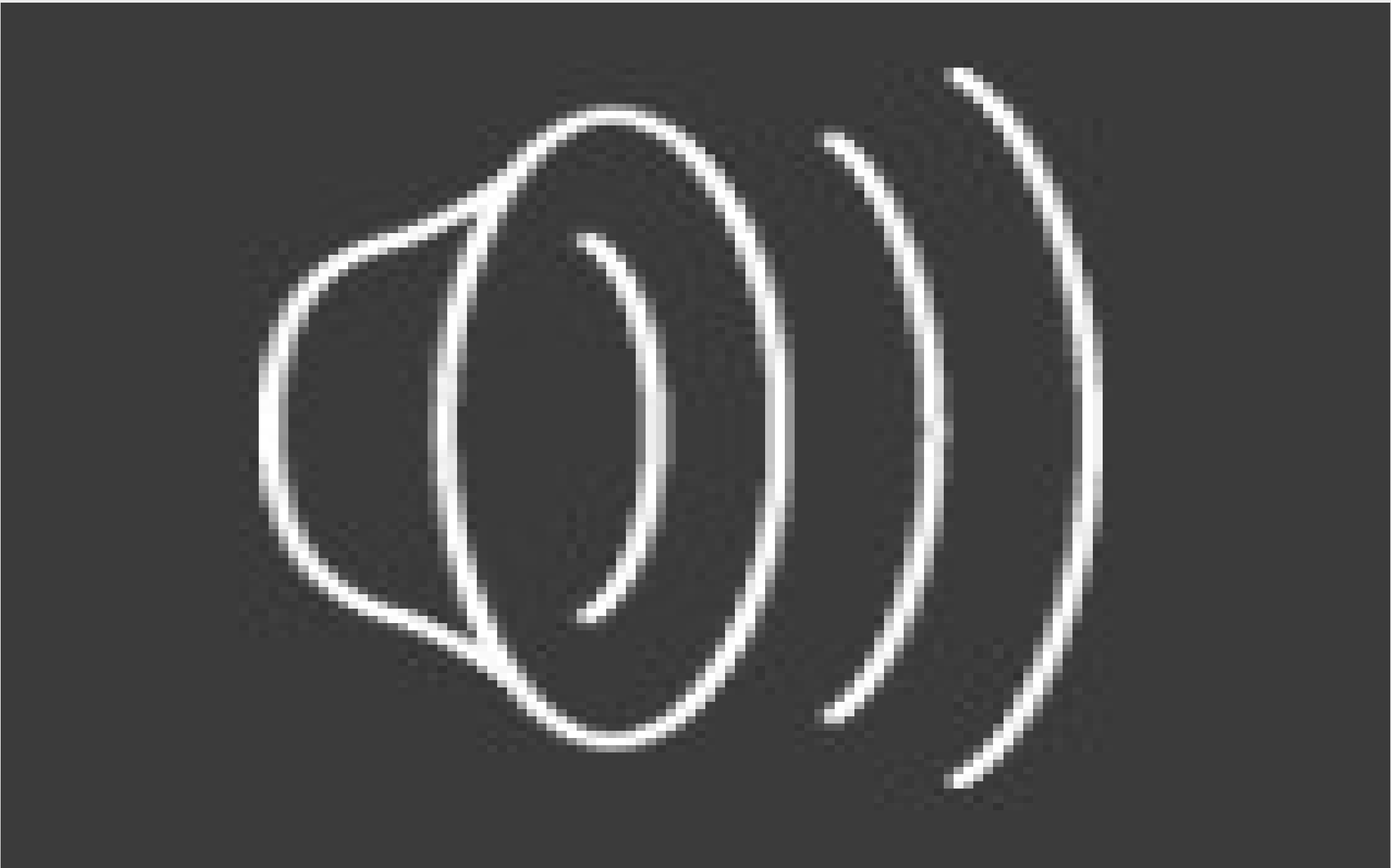
- The same two approaches
- Procedure for ensuring marker tracking stability
- Height controller → reduce height while landing
- If the quadrocopter is too low to see the marker → stabilize the position → land

Autonomous Part - Evaluation

- Both approaches were compared
  - Distance from landed position to marker used as metric
  - Static landing pad in this case
  - 15 Trials for both cases

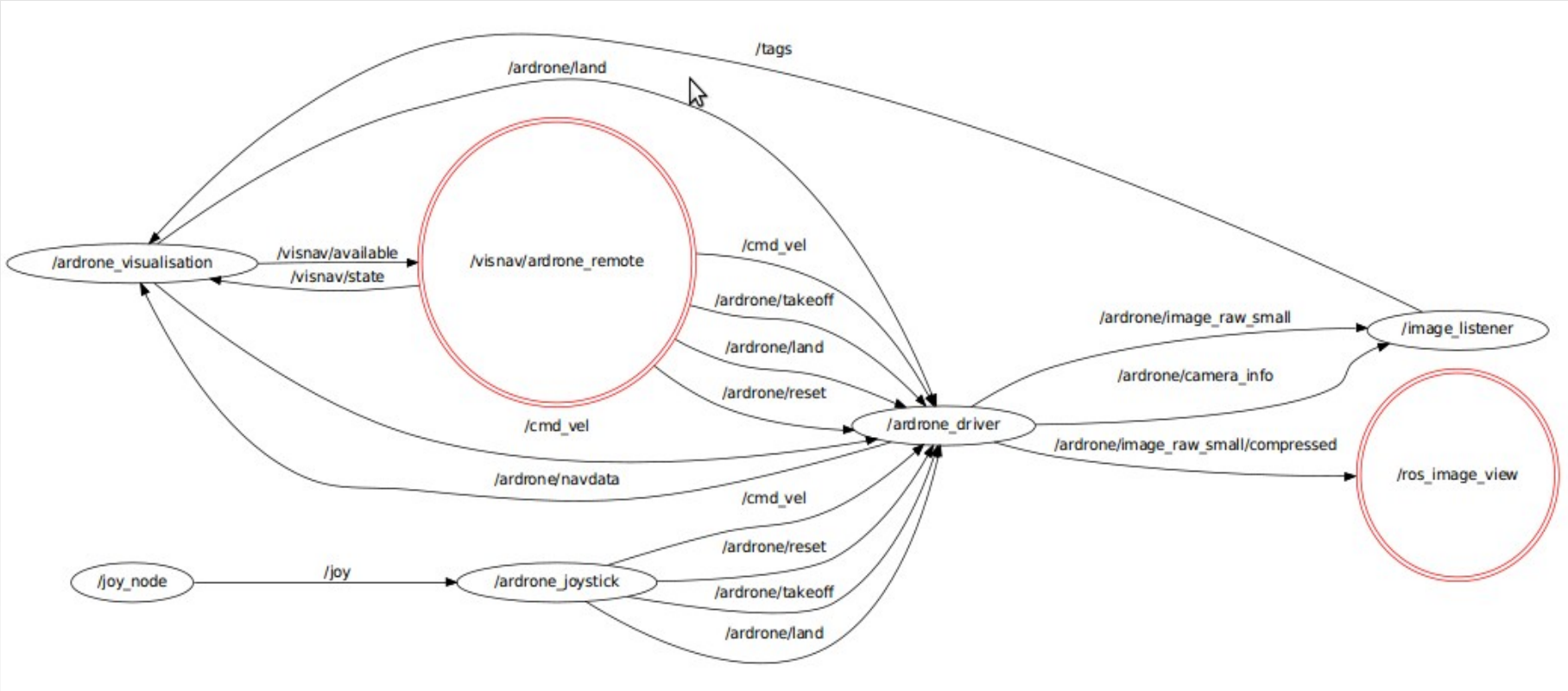
	Beta marker (landing marker not used for localization)	Zeta marker (landing marker used for localization)
Ave. dist	19.7cm	34.5cm
Ave. dist (exl. Misses)	11.1cm	18.1cm
st. dev (exl. Misses)	6.3cm	10.9cm
# misses	3	6
Ave. time taken	31.14s	34.08s

Autonomous Part - Result



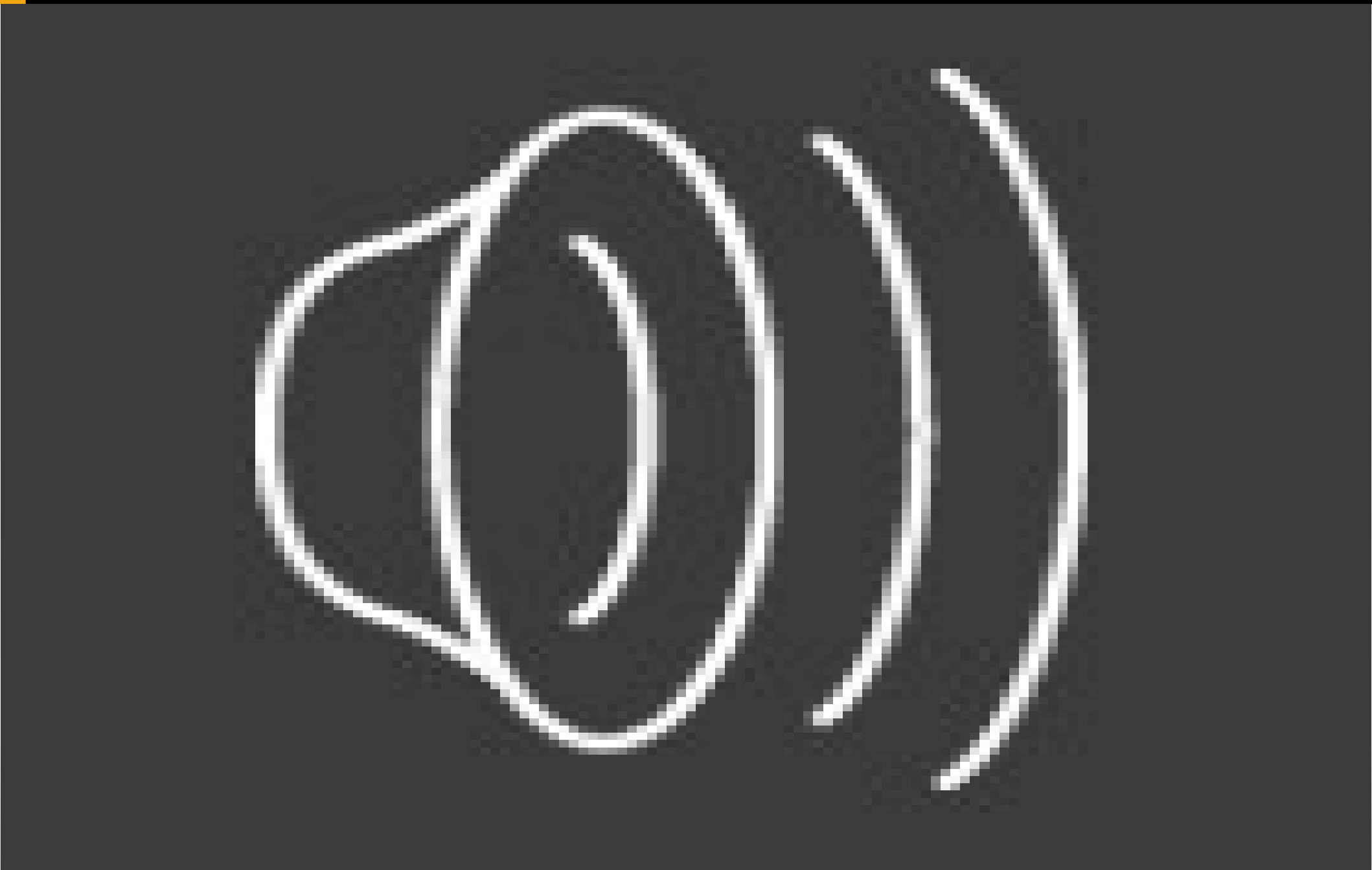
Combining two parts

- Architecture



- Problems

Final Result



Conclusions

- Possible improvements
  - More stable controller
  - Transfer the software to the cell phone
  - Motion model
  - Markerless tracking/landing
- Applications
  - Autonomous re-charging
  - Explore and return home
- Experience gained during the project

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Questions?

Thank you for your attention.